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A Study to Determine the Combined Effects of Car and Driver Factors on Fuel Conservation

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ABSTRACT

The present study was carried out to evaluate the possible fuel savings attainable through improving a combination of the most common fuel inefficient car factors and driver actions for one car.

Results indicate a fuel savings of 47% is possible when certain poor driving habits and fuel ineffficient car factors are improved. Car factors accounted for a 23% fuel loss while poor driving habits consumed an additional 24%.

Although these results will vary depending on the specific car and driver, they demonstrate that close to half of the fuel in each tankful can be wasted.

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1/ INTRODUCTION

Transportation in general and automobiles in particular are major petroleum consumers. The transportation sector uses almost half (49%) of all the oil used in Ontario with 56% of that amount being directly attributable to automobiles. Overall, automobiles account for one out of every four barrels of oil consumed in Ontario.

Because automobiles are such major fuel consumers, the Ontario government has established DriveSave, a program to improve the fuel economy of Ontario's drivers. DriveSave is an integral part of the Transportation Energy Management Program (TEMP).

As a first step in the program, a reference document was developed through a review of literature and interviews with auto, tire and oil manufacturers. Results indicated that a large number of fuel saving actions were available to drivers. Separate studies have dealt with the fuel conservation that can be attained by changing driver behaviour or improving certain car maintenance factors. These studies show that changing driver habits by using specific fuel efficient driving techniques can effect fuel savings of up to 15% [3, 4, 5, 6], while improving car maintenance resulted in approximately a 4.2% saving of fuel [10]. Other factors such as not overloading the trunk, decreasing aerodynamic drag, maintaining adequate tire pressures, using a good friction modified oil and using a block heater in cold winter months appear to increase fuel efficiency [1].

Each of these studies provides an estimation of the effectiveness of a single driver action or a small set of driver actions. However, to date, there are no studies which evaluate the overall fuel savings attainable through a combination of all these actions.

When added up separately, these theoretical total savings are impressive, but appear to be quite unrealistic. As a result, the present demonstration intended to delineate the maximum potential fuel savings that can occur under a specific set of conditions. The next section will focus on defining the driving techniques and car maintenance practices that are to be considered as well as providing the potential savings of these factors.

2/ FUEL EFFICIENT DRIVING FACTORS

A number of studies have defined several fuel efficient driving techniques which, when applied together, appear to make a difference of up to 15% in overall fuel consumption. These techniques include acceleration and deceleration practices, stopping, idling and generally keeping in the traffic flow.

Specifically, a vehicle which coasted a distance before brakes were applied and in which the driver avoided jabbing his/her foot on the throttle, obtained better gas mileage than the same vehicle in a control session when these practices were not followed. Taking 15 s to reach a speed of 50 km/h [4] and letting speed fall somewhat while going uphill rather than accelerating vigorously [1] were two other techniques found to be fuel efficient.

In urban situations, both the traffic flow and unnecessary stops need to be taken into account. In one study, drivers who kept up with the traffic flow and who made speed adjustments in order to avoid unnecessary stops showed a greater amount of fuel conservation than any other group including those who decreased or increased speed with respect to the overall traffic flow [6]. It was also pointed out in this study that idling consumes more fuel than used by a car moving at a constant speed of 60 km/h. A further study suggested the importance of following distance to fuel efficiency, in that following at a proper distance would tend to decrease the overall number of stops and starts a driver was required to make in fairly heavy traffic [7].

In highway driving, adhering to the speed limit or just below is shown to have a large effect on fuel consumption. One calculated estimate of fuel used suggests that 10% additional fuel is used for every 10 km/h over legal highway speeds [1].

As well, in cold weather, block heaters are an additional source of fuel savings. One study suggests as much as 5 to 8% can be saved by their use [9].

In summary, the driving techniques to be included for pre-post comparison in the present study include:

1/ Moderate acceleration practices so that a speed of 50 km/h is attained in about 15 s;

2/ Anticipating stops well in advance by taking foot off the accelerator and coasting to a stop wherever possible;

3/ Anticipating traffic lights;

4/ Staying within speed limits;

5/ Allowing speed to fall off somewhat while going uphill;

6/ Driving with the traffic flow but anticipating it well in advance so that a wait behind stalled cars or slow moving vehicles can be avoided;

7/ Turning engine off when parked or stopped on an errand;

8/ Using a block heater in cold weather.

The potential fuel savings from these factors appear to be in the vicinity of 23%, with 15% savings expected from driving techniques and approximately 8% savings due to both the use of a block heater and the elimination of a one minute idle for a short stop.

2.1/ Car Factors

Studies have shown that there are several car factors that can provide fuel savings. One study suggests that a tuneup done approximately once a year can provide potential savings of 4.2% yearly [10]. This tuneup consists basically of adjusting the idle mixture, idle speed and ignition timing with the provision that idle carbon monoxide (CO) would be brought down to 2% or less of total emissions.

A further study points out that changing the oil from a general all purpose one to a friction modified oil and changing from bias ply tires to radials would also provide some fuel savings [1]. This study also contends that windows be kept closed at highway speeds and flow-through ventilation be used wherever possible; that roof racks be removed when no longer necessary; that extraneous objects be removed from the trunk and that tires be inflated to the specifications on the sidewalls.

This last point is an important one, in that a study conducted by TEMP [2] found that the average underinflation from tire manufacturers' recommended pressures was approximately 56 kPa (8 psi). Since fuel economy decreases by 1% for every 14 kPa (2 psi) of underinflation, this suggests that the average fuel loss due to tire underinflation is approximately 4%.

In summary, the potential fuel savings from changing a number of car factors is expected to be about 22%. This figure is compiled from a number of sources [1, 10, 11] and includes the following: bias ply tires 7%; underinflation 4%; roof rack 5%; weight in back seat 2%; oil 1% and CO and idle speed adjustments 2 to 3%. However, the estimation is only a rough one, in that many of the factors increase exponentially and not linearly with increasing velocity and therefore can only be approximated. In addition, it is unclear whether the savings are additive.

Altogether, fuel savings from car and driving factors are expected to be somewhere around 44%. This figure is based on adding individual factors according to the results obtained from separate studies. The present demonstration is meant to determine whether such a high fuel gain does in fact occur when all fuel efficient methods are used at once.

3/ METHOD

3.1/ Sample

Two student drivers were used as subjects. One driver was instructed how to drive in both Phase 1 and Phase 2 (I driver). The other driver was asked to drive fuel efficiently throughout the study (FE driver).

3.2/ Procedure

The test route was a standarized 13 km course with approximately equal amounts of freeway, urban residential streets and arterial roads.

The test car was a 1980 six cylinder Ford Fairmont. Gasoline consumption was measured using the tank weighing method: two explo-safe auxiliary fuel tanks were placed in the trunk with extra fuel lines running to the engine. A gas tank was removed and weighed before and after each circuit to determine the amount of fuel used during that specific run. Gas volume was subsequently calculated by dividing the weight of the fuel by its specific gravity.

The demonstration comprised two phases. Phase 1 included 'detuning' the car to average CO and idle rpm values obtained from a recent MTC study [10], as well as introducing other fuel inefficient factors such as bias ply tires, tire underinflation, a roof rack and 45 kg weight in the back seat. All these factors were corrected in Phase 2. Table 1 provides the relevant variables.

In addition, during Phase 1, the instructed driver (I driver) was asked to drive fuel inefficiently, according to the techniques set out in Table 2, Phase 1, while the FE driver was asked to drive fuel efficiently. During Phase 2, both drivers were asked to drive fuel efficiently. Table 2 is a summary of the relevant techniques.

Throughout both phases the I driver always drove first in order that the effects of a five min cold start idle in Phase 1 vs. block heating in Phase 2 could be measured. Ideally, only one daily run (the morning one)

should have been made by each driver, however, due to time constraints each driver made two daily runs. Morning runs were made after 9 a.m. and afternoon runs were made after 1:30 p.m.

After a few preliminary practice runs, each driver went around the 13 km course twice a day for nine days with the car in the condition outlined in Table 1, Phase 1, with the I driver driving fuel inefficiently. The procedure was repeated twice a day for the following nine days with the car in the condition outlined in Table 1, Phase 2 and the I driver driving fuel efficiently. The data allowed calculations to be made for: 1/ car factors alone (from 'detuned' to tuned); 2/ car factors plus driving habits; and 3/ driving habits alone. The relevant variables are depicted in Table 3 (experimental design).

3.3/ Results

The two daily runs were averaged for each driver. Results are depicted in Figure 1.

On the average, overall percent improvement between Phases 1 and 2 for car factors and driving practices (I driver) was 46.8% with an 8.4% loss in travel time (1.5 min longer in Phase 2 than in Phase 1).

Improvement due to car factors alone was 23%, while improvement due to a changeover from bad to good driving habits was 24%. The results are summarized in Table 4.

3.4/ Discussion

The overall results from the present demonstration showed that a 47% fuel loss can occur as a result of poor driving habits together with certain adverse car factors. This actual amount is very close to estimated amounts when the same factors are added together separately.

Car factors alone can account for 23% of fuel loss while poor driving habits can waste up to an additional 24%. This means that, depending on the specific car and driver, close to 50% of the fuel in each tankful can

be wasted unnecessarily. This is a substantial amount given that the average driver spends close to one thousand dollars a year on gas (1981-1982).

The results, however, reflect the maximum (or close to the maximum) potential that can be achieved when fuel inefficient drivers follow fuel efficient practices. It should be noted that the number of fuel inefficient driving styles and car factors vary from driver to driver, depending on the specific car and driver. The demonstration, therefore, is an effective guideline as to the degree of fuel savings that can be attained, but does not reflect what drivers can save individually.

4/ REFERENCES

[1] A Background Document for Education Messages on Automotive Fuel Economy prepared for the Ministry of Transportation and Communications and the Ministry of Energy, DriveSave Program.

[2] Blackman, A.K., Results Obtained From Public Clinics Held to Demonstrate Fuel Economy Maintenance, MTC, TEMP, DRS-82-02, December 1981.

[3] Claffey, Paul J., Automobile Fuel Economy and the Driver, presented at the annual meeting of the Transportation Research Board, D.C., January 1979.

[4] Evans, L. and Takasaki G.M., Fuel Used to Accelerate Vehicles from Rest to Cruising Speeds, GMR-3555, Transportation and Traffic Science Department, General Motors Laboratories, Warren Michigan.

[5] Evans, L., Herman R. and Lam T., "Multivariate Analysis of Traffic Factors Related to Fuel Consumption in Urban Driving," Transportation Science, May 1976, 10 (2), pp. 205-215.

[6] Evans, L., "Driver Behaviour Effects on Fuel Consumption in Urban Driving," Human Factors, 1979, 21 (4), pp. 389-398.

[7] Hubbard, Jones M. and Appleby M.R., Driver Performance and Fuel Economy, proceedings of the Human Factors Society, 1978.

[8] Wasielewski, P., Evans L. and Chang M., Automobile Braking Energy, Acceleration and Speed in City Traffic, SAE, Passenger Car Meeting, 1980.

[9] Wood, P.S., Fuel Conserving Driving Practices: A Preliminary Assessment of Potential Savings Using Computer Simulation, MTC, May 1979.

[10] Wood, P.S., The Effect of Specific Vehicle Maintenance Measures on Fuel Consumption, Prepared for the Ministry of Transportation and Communications and the Ministry of Energy, TEMP Program.

[11] Organization for Economic Cooperation and Development, final report of the Round Table on Automobile Fuel Consumption in Realistic Traffic Conditions (Working Document), Road Research Programme, Paris, 1981.

TABLE 1/ CAR FACTORS

NON FUEL EFFICIENT (PHASE 1)	FUEL EFFICIENT (PHASE 2)
- ROOF RACK	- NO ROOF RACK
- WEIGHT IN BACK SEAT 45 kg.	- NO WEIGHT
- OPEN WINDOWS (WHEN FEASIBLE)	- USE FLOW-THROUGH VENTS (WHEN FEASIBLE)
- BIAS PLY TIRES	- P-METRIC RADIALS OR RADIALS
- TIRES INFLATED TO 165 kPa (24 psi)	- TIRES INFLATED TO 221 kPa (32 psi)
- SAE 10W40 OIL	- SAE 5W30 OIL
- CO: 2% (PROVINCIAL MAX) IDLE SPEED: 103 Rpm ADVANCED	- CO: <0.1% IDLE SPEED: TO SPECIFICATION

TABLE 2/ DRIVING SKILLS

NON FUEL EFFICIENT (PHASE 1)	FUEL EFFICIENT (PHASE 2)
- NO BLOCK HEATER IDLE 5 min WARM ENGINE	- USE A BLOCK HEATER START AND GO
- STOP 1 min: LEAVE IGNITION ON	- STOP 1 min: TURN IGNITION OFF
- FAST ACCELERATION 9 s TO 50 km/h	- SLOWER ACCELERATION 15 s TO 50 km/h
- KEEP ACCELERATOR DEPRESSED UNTIL NEED TO APPLY BRAKE	- ANTICIPATE STOPS AND COAST WITH FOOT OFF ACCELERATOR
- CHANGE LANES TO PASS CARS WHENEVER POSSIBLE	- KEEP IN TRAFFIC FLOW AND ANTICIPATE TRAFFIC AHEAD
- HIGHWAY DRIVING: 100 km/h	- HIGHWAY DRIVING: 90 km/h
- ACCELERATE GOING UP HILLS	- LET SPEED DROP OFF GOING UP HILLS

TABLE 3/ EXPERIMENTAL DESIGN

	PHASE 1 CAR 'DETUNED'	PHASE 2 CAR TUNED
INSTRUCTED DRIVER	A DRIVE FUEL INEFFICIENTLY	B DRIVE FUEL EFFICIENTLY
FUEL EFFICIENT DRIVER	C DRIVE FUEL EFFICIENTLY	D DRIVE FUEL EFFICIENTLY

DATA:

CAR VARIABLES: C - D = X

DRIVER VARIABLES: (A - B) - X

CAR AND DRIVER VARIABLES: A - B

TABLE 4/ RESULTS

	IMPROVEMENT
ALL FACTORS (CAR PLUS DRIVING)	47%
DRIVING	24%
CAR	23%
	TIME LOSS
BAD TO GOOD DRIVING	8.4%

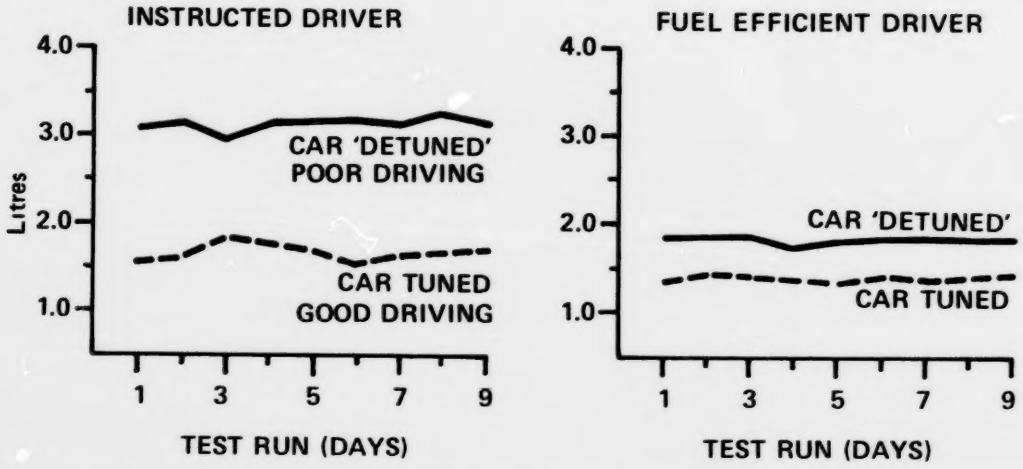

FIGURE 1/ AVERAGE FUEL CONSUMPTION FOR INSTRUCTED AND FUEL EFFICIENT DRIVERS OVER 9 TEST RUNS: CAR 'DETUNED' vs. CAR TUNED.